

Application No. 10/812,947
Reply to Office Action of October 6, 2006

IN THE DRAWINGS

The attached sheet of drawings includes changes to Fig. 3. This sheet, which includes Fig. 3, replaces the original sheet including Fig. 3.

Attachment: Replacement Sheet

REMARKS/ARGUMENTS

Favorable reconsideration of this application in light of the present amendments and following discussion is respectfully requested.

Claims 1-10 are presently active.

In the outstanding Office Action, The title of the invention was objected to for not being descriptive. Figure 3 was objected to for not having a legend such as --Prior Art--. Claims 1-3 and 6-8 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Moku et al (Japanese Publication No. 2003-059948-Translation) in view of Applicant's Figure 3. Claims 4, 5, 9 and 10 were objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Firstly, Applicant acknowledges with appreciation the indication of allowable subject matter in Claims 4, 5, 9 and 10.

Secondly, the objection to the title and the objection to Figure 3 have been addressed by the present amendment. Thus, it is respectfully submitted that these issues have been overcome.

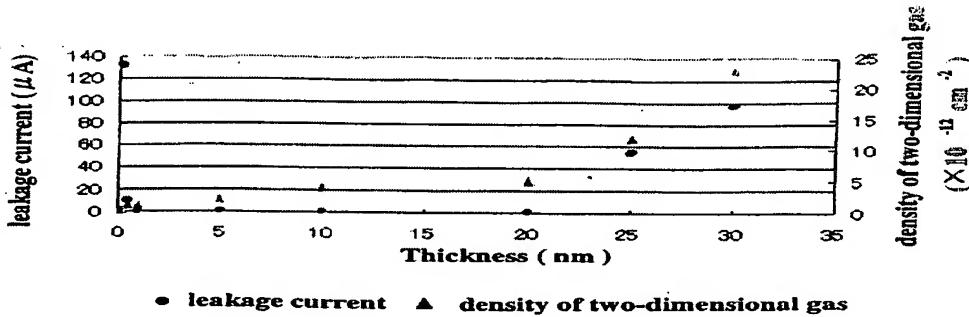
Thirdly, regarding the rejection on the merits, Claim 1 defines that first buffer layer and second buffer layer have a two-dimensional electron gas density or densities therein not greater than $5 \times 10^{12} \text{ cm}^{-2}$. Claim 2 defines that each of first buffer layer and second buffer layer have a thickness of not less than 0.5 nm and not greater than 20 nm for achieving the two-dimensional electron density defined in Claim 1.

The present invention achieves a reduction of the leakage current through the use of appropriately sized buffer layers. It is known that a hetero-junction interface between layered buffer layers of different bandgap energies have therein a polarization and thus are likely to produce a two-dimensional electron gas. Applicant submits that Moku et al describes a

HEMT device which uses a two-dimensional gas generated in a hetero-junction interface as channel electrons (see paragraph 0005).

However, it has been found by the present inventor that, in a plurality of buffer layers forming the hetero-junction interface, there occurs therein a two-dimensional electron gas causing leakage current. Thus, in the present invention, the density of the two dimensional gas is controlled within a specific range (through for example appropriate control of the size of the buffer layers) to thereby achieve a reduction in the leakage current.

The data tabulated in Table 1 of the specification (see page 15) is reproduced in the following graph:



In this graph, the thickness (nm) of the buffer layers is plotted on the abscissa, whereas the leakage current (μA) and density ($\times 10^{-12} \text{ cm}^{-2}$) of the two-dimensional electron gas are plotted on the ordinate. Circle dots represent the leakage current, whereas the triangle-dots represent the density of the two-dimensional electron gas.

As seen in the graph, a film thickness of first and second buffer layers exceeding 20 nm causes an abrupt increase of the leakage current and also increases the density of the two-dimensional electron gas in the buffer layers. This leads to a presumption that the increase of the leakage current results from the increase of the density of the two-dimensional gas.

Although the leakage current increases even below a thickness of 0.5 nm in the graph, this leakage current is considered to occur because of defective dislocations caused by a lattice mismatching in the crystal structure of the buffer layers. Applicant submits that the

occurrence of the leakage current caused by the two-dimensional electron gas in the buffer layers was not known in the art at the time of the present invention, and was thus unexpected prior to the present invention.

That is, the present inventor found as illustrated in the graph above that the density of the two-dimensional electron gas abruptly increases if the thickness of both the first and second buffer layers exceeds 20 nm, and conceived that first and second buffer layers of a thickness not greater than 20 nm suppress the density of the two-dimensional gas down to or below $5.0 \times 10^{-12} \text{ cm}^{-2}$ and thereby reduce the leakage current.

Regarding Moku et al, Moku et al describe a buffer layer structure including first and second layers, similar to the present invention. However, Moku et al is silent to the fact that the layered buffer structure causes the occurrence of the two-dimensional gas in the buffer layers, that the two-dimensional electron gas in the buffer layers increases the leakage current, and that the increase or decrease of the density of the two-dimensional gas as well as the leakage current depends on the thickness of the buffer layers configuring the hetero-junction interface in between. Without the unexpected results on the present invention, one of ordinary skill in the art at the time of the invention would not know how to set the layer thicknesses of the buffer layers in Moku et al in order to reduce leakage current.

For instance, while the Office Action correctly states that Moku et al describes in paragraph 0008 thereof that the first layer preferably has a thickness of 0.5 to 50 nm and the second layer preferably has a thickness of 0.5 to 200 nm, the first embodiment of Moku et al described in paragraph 0023 describes that the first layer has a thickness of about 10 nm whereas the second layer has a thickness of about 30 nm and the third embodiment in paragraph 0036 discloses that the first layer has a thickness of about 5 nm whereas the second layer has a thickness of about 30 nm. That is, Moku et al do not show the claimed configuration (Claim 2) of the present invention in which both the first and second layers

have a thickness not greater than 20 nm at the same time. Therefore, Moku et al do not disclose or suggest the claimed electron density configuration (Claim 1) of the present invention. Indeed, the Office Action assumes on the basis of there being “the same material” in Moku et al as in the present invention that the properties will be the same.¹ Yet, as seen from the data in the graph above, this position does not necessarily follow.

Accordingly, with one of ordinary skill in the art at the time of the present invention having *no knowledge* Applicant’s unexpected association of the thickness of the buffer layers to the two dimensional gas density and to a reduction in the leakage current, the configuration of the present invention would not have been conceived based on teaching of Moku et al. Furthermore, the deficiencies in Moku et al are not overcome by Applicant’s Figure 3.

Thus, Claim 1 and the claims dependent therefrom are believed to patentably define over Moku et al.

¹ Office Action, page 3, lines 17-21.

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Consequently, in view of the present amendment and in light of the above discussions, the outstanding grounds for rejection are believed to have been overcome. The application as amended herewith is believed to be in condition for formal allowance. An early and favorable action to that effect is respectfully requested.

Respectfully submitted,

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